Journal of the American College of Cardiology
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Published by Elsevier Inc.

Vol. 48, No. 10, 2006
ISSN 0735-1097/06/$32.00
doi:10.1016/j.jacc.2006.09.001

Editorial Comment

Coronary MRI

More Pretty Pictures or Present-Day Value?*

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The noninvasive evaluation of the coronary arteries has been a major goal of cardiovascular imaging. This has been difficult to accomplish because the coronary arteries are small, have similar imaging characteristics to the surrounding myocardium and cardiac veins, and are in constant motion. Two modalities, coronary magnetic resonance imaging (MRI) and coronary computed tomographic angiography (CTA), have had success addressing these problems in very different ways.

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The coronary arteries are generally <5 mm in diameter, and vessels as small as 2 mm can be treated with percutaneous intervention. Successful imaging of these small vessels requires spatial resolution of <1 mm. For coronary CTA, high spatial resolution has come about with the introduction of 16- and 64-slice multidetector machines that use significant doses of radiation to generate isotropic voxel sizes with a spatial resolution approaching 0.5 mm (1). Obtaining in-plane submillimeter spatial resolution with coronary MRI at 1.5 T has required maximizing the signal-to-noise ratio by using anisotropic voxel sizes and implementing novel image acquisition sequences that generally require a prolonged imaging time. For many years, a targeted 3-dimensional volume approach has been advocated in which the left and right coronary arteries are imaged separately, with 2-mm to 3-mm slice thickness and in-plane resolution of approximately 0.8 mm (2).

Because the coronary artery lumen is principally filled with water, it has similar imaging characteristics to the nearby myocardium and the cardiac veins. Coronary CTA requires the use of iodinated contrast material to provide sufficient contrast from these surrounding structures, which is associated with a low but significant rate of morbidity. Generally an initial timing bolus is required to determine the circulation time for correct timing of image acquisition. Some vendors have implemented contrast bolus tracking such that a timing bolus is not required and the entire imaging process can be accomplished with the push of a single button. With MRI, coronary artery contrast is generated by using specific imaging sequences and prepulses without exogenous contrast administration.

Both CTA and coronary MRI use electrocardiographic (ECG) gating, an absolute requirement for the suppression of cardiac motion. With CTA, image data are acquired throughout the cardiac cycle simultaneously with an ECG tracing. This allows for retrospective image reconstruction at multiple intervals such that interpretable images can be acquired in nearly all patients who are in sinus rhythm. Improvements in gantry speed now allow for reconstruction intervals as short as 165 ms with single-source machines and 83 ms with dual-source machines (3). Beta-blockade is usually required to lower the heart rate to <60 beats/min. With coronary MRI, data can be acquired at any time within the cardiac cycle, but this time interval and duration must be determined prospectively so as to properly position prepulses. The reconstruction interval is usually in mid-diastole when right coronary artery motion is minimal and coronary blood flow is high. The duration of data acquisition can vary from 50 to 150 ms per cardiac cycle, with the acquisition extending for several minutes.

Suppression of ventilatory for 64-slice multidetector CTA is accomplished with a single sustained breath hold of <15 s. Because the imaging time for sub-millimeter resolution coronary MRI is usually several minutes, breath holding is not possible. Imaging is commonly performed during free breathing with diaphragmatic navigator tracking and correction. Irregular breathing patterns can result in poor image quality, but the lack of ionizing radiation and iodinated contrast facilitates repeat imaging.

For both CTA and coronary MRI, raw image datasets are transferred to a workstation for further analysis. The CTA workstations are equipped with numerous reformatting options so that the coronary tree can be evaluated with relative ease. Coronary CTA post-processing tools are quite advanced, allowing for visually appealing display of the images that has created great enthusiasm in the medical community despite the relatively high radiation dose and the use of iodinated contrast. These postprocessing options have not yet become available on commercially available MRI workstations.

In general, advances in coronary CTA have come about through the introduction of new hardware (increasing the number of detectors, faster gantry speed, and dual sources),

*Editorials published in the *Journal of the American College of Cardiology* reflect the views of the authors and do not necessarily represent the views of *JACC* or the American College of Cardiology.

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November 21, 2006:1951–2

whereas coronary MRI advances are based on innovations in sequence and timing software and remain more demanding for both the patient and the operator. The optimal coronary artery imaging technique would accurately determine the presence of obstructive coronary disease and combine the speed and simplicity of CTA with the endogenous contrast, lack of ionizing radiation, and relative heart rate insensitivity of coronary MRI.

In this issue of the *Journal*, Sakuma et al. (4) report progress in coronary MRI by building on their prior experience (5) using whole-heart coronary MRI with steady-state free-precession imaging but inferior in-plane spatial resolution of 1.1 mm and slice thickness of 1.5 mm. The overall approach is somewhat analogous to CTA, with delineation of the superior and inferior bounds of the heart to define a single imaging volume that includes both coronary arteries (6). They coupled this technique with new software reformatting options. The clinical results are impressive with per-patient sensitivity of 82% and specificity of 90% and with overall accuracy of 87%. The segment negative predictive value was 98%. These data are superior to the multicenter targeted 3-dimensional volume results but similar to other single-center coronary MRI data (7–10).

Although Sakuma et al. (4) attempted to improve the reliability of this technique using patient-specific acquisition intervals as determined by ECG-gated cine images of the right coronary artery, 18 of 131 (14%) patients had uninterpretable images, similar to the multicenter trial data. This was most likely related to navigator errors caused by irregular breathing patterns. Future advances in the reliability of coronary cardiac magnetic resonance (CMR) imaging may require further improvements in respiratory motion suppression methods or very rapid single breath-hold acquisitions using parallel imaging with high-field systems (11).

There are some concerns about the interpretation of the coronary MRI and invasive angiography data. It is not stated whether the coronary MRI data were acquired before invasive coronary angiography or if they were interpreted in a blinded manner. In particular, patients with stents were included in the study. Because stents are readily evident on CMR images, this may have led to a biased interpretation of the images. Patients received sublingual nitrates before CMR but not before x-ray angiography. Unfortunately, the invasive X-ray angiography results were not assessed using objective quantitative coronary angiography and the CMR images were interpreted using proprietary software that is not commercially available, nor are data on the specific value of the software tool presented. Confirming these results may therefore be difficult.

As with most studies assessing noninvasive coronary artery imaging, the patient cohort was composed of patients who were referred for invasive coronary angiography. This is a high-risk population that is enriched with coronary artery disease, with a prevalence of 47% in this cohort. If this technique is to be used only in this population, then these results can be readily generalized. However, noninvasive coronary imaging is being advertised as a screening test for those with atypical symptoms or multiple risk factors. Although the sensitivity and specificity of this technique should not vary in populations with differing probabilities of disease, the positive and negative predictive values may vary greatly. If applied to lower-risk populations, the number of false-positive results may be unacceptably high, resulting in an increased number of patients potentially treated for coronary artery disease and referred for invasive coronary angiography. At our institution, we offer coronary MRI as a clinical tool for discriminating ischemic from nonischemic cardiomyopathy in those patients with left ventricular systolic dysfunction. Recent data suggest that coronary CMR is superior to delayed-enhancement CMR for this indication (12).

The report from Sakuma et al. (4) shows that whole-heart coronary MRI can be performed relatively quickly and easily with promising clinical results. As with coronary CTA, the clinical role of coronary MRI remains to be defined by multicenter trials. We need to define the value behind the pretty pictures.

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